OIL-IMPREGNATED ROCK DEPOSITS OF UTAH

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GEOGRAPHIC DISTRIBUTION

Utah's 53 deposits of oil-impregnated rock are mainly grouped within and around the Uinta Basin of northeast Utah and in the central southeast part of the State; twenty-five deposits are in the Uinta Basin and 22 in the central southeast. Six minor or small deposits occur in the northwest, southwest and far southeast parts of the State.

GEOLOGIC DISTRIBUTION

Uinta Basin

Twenty-three of 25 deposits in the Uinta Basin contain oils which almost certainly originated in source beds of Tertiary age, most probably the lacustrine Green River Formation. In about 13 of the 23 deposits, the oil has remained in the Green River Formation or in the Wasatch immediately beneath. These *in situ* deposits are mostly on the gentle south flank of the basin. On the strongly folded and faulted north flank of the basin, oil traps apparently were ruptured causing oil to migrate into younger or older formations depending on the structural situation (migrated deposits). The Whiterocks deposit contains Tertiary oil in the Jurassic Navajo Sandstone. In six deposits, oil has moved upward into porous sands of the Duchesne River Formation. At Asphalt Ridge, oil occurs in sandstones above and below the unconformable contact of the Duchesne River Formation with the underlying Mesaverde Formation (Upper Cretaceous). At Asphalt Ridge Northwest, Tertiary oil occurs in a lower Mesaverde sandstone. In the central part of the basin, oil apparently moved upward along faults and fractures and lodged in the Uinta Formation (Pariette and Chapita Wells deposits).

Only one Uinta Basin deposit, Split Mountain, contains certain Paleozoic oil in Permian rocks. The Daniels Canyon deposit in Permo-Pennsylvanian rocks probably contains oil which migrated upward along fractures through an extensive overthrust sheet from Tertiary rocks beneath the thrust.

Central Southeast

Most of the oil in deposits in central southeast Utah is contained in rocks of Permian and Triassic age, most of it in the Permian White Rim Sandstone in the Tar Sand Triangle. The amount of oil found in Triassic formations in the San Rafael Swell and the Circle Cliffs is remarkable considering the sparse productive record of Triassic formations in Utah's oil fields.

Scattered occurrences of oil in Cretaceous and Jurassic formations in the area are of scientific interest, but of little commercial value.

The deposits of the Tar Sand Triangle, Circle Cliffs and San Rafael Swell are considered primarily *in situ* deposits. In the Tar Sand Triangle considerable downward gravity migration has occurred after the original trap was breached by erosion and the water drive dispersed.

The Salt Wash, Sweetwater Dome, Ten Mile Wash and Thousand Lake Mountain deposits appear to be the only migrated deposits in the central southeast region.

Other Areas

Six more deposits are scattered in other areas of Utah. Four deposits, occur in the Moenkopi Formation (Triassic) in Washington County, southwestern Utah. The Rozel deposit occurs along the shore of the north arm of Great Salt Lake. Here small quantities of an unusual oil rise along a fault and saturate Recent muds and salt on the lake shore. The deposit is submerged during high water.

Oil-impregnated limestone reefs in the Hermosa Formation (Pennsylvanian) along the Canyons of the San Juan River in southeast Utah comprise the oldest deposit in Utah.

LITHOLOGY OF DEPOSITS

Most deposits, particularly those of major size, occur in sandstone which, with finer grain size, grades into siltstone and, with coarser grain size, grades into grit and conglomerate. More than 99 percent of the estimated oil in place in Utah's deposits is contained in sandstone and siltstone.

Along the south flank of the Uinta Basin, the Argyle Canyon, Minnie Maud Creek and Willow Creek deposits contain notable amounts of oil-impregnated limestone in the Green River Formation. The Thistle deposit, also in the Green River, contains considerable heavily impregnated oolitic limestone and coquina. The Split Mountain deposit occurs in coarse crystalline and vuggy Park City Formation limestones. The Daniels Canyon deposit occurs in highly fractured quartzite and siliceous limestone.

In central southeast Utah all deposits are contained in sandstone, siltstone and some conglomerate, except for small amounts of oil-impregnated limestone found in San Rafael Swell and Teasdale deposits and localities.

In southwest Utah, three deposits are in limestone or sandy limestone. The North Creek deposit occurs in sandy shale and shale.

The Mexican Hat deposit (San Juan County) occurs in Pennsylvanian carbonates and the Rozel deposit (Box Elder County) is found in oolitic mud and salt on the shores of Great Salt Lake.

ORIGIN, MIGRATION AND ENTRAPMENT

Oil contained in these deposits originated in the same way as oil found in conventional oil fields. The source was organic material contained within rocks laid down in situations in which the organic material was converted to petroleum. The petroleum has been trapped by fortuitous stratigraphic or structural conditions close to its area of origin (*in situ* deposit) or has migrated unknown distances to become trapped at another locality (migrated deposit). Since the oil in oil-impregnated rocks is exposed to the atmosphere, volatile constituents usually found in conventional oil and gas fields at depth have escaped. The oil has also been degraded by bacterial action and altered by contact with oxygen-rich fresh water. The oil in oil-impregnated sandstone deposits is, therefore, "heavy", viscous, and has a low gravity rating. Usually the quality of the oil increases with distance from outcrop exposure and with increasing depth.

Oil migration may have taken place laterally along bedding planes, through permeable sandstone or limestone or along lateral or vertical conduits formed by faults, fractures and joints. Studies of many deposits show that fractures and joints associated with faulting are important migration routes. Faults frequently form barriers to migration and may cause entrapment. However, stratigraphic factors, principally porosity and permeability variation, appear to be much more important than structure.

Deposits along the structurally complex north flank of the Uinta Basin from Daniels Canyon on the west through Rim Rock on the east result from rupture and tilting of deep-seated traps with oil escaping to the outcrop along faults, bedding planes, fractures and joints. All oil appears to have originated in the Green River or Wasatch Formations with migration following various conduits upward and laterally for many miles.

The deposits from Raven Ridge around the east and south flanks of the Uinta Basin are gigantic stratigraphic traps in which oil from the highly petroliferous Green River Formation was trapped in porous sandstones in the Green River and underlying Wasatch Formation close to its area of origin. Deposits such as P. R. Spring and Sunnyside are actually giant oil fields breached by erosion.

In the central southeast area of Utah, oil in the deposits in the Tar Sand Triangle apparently originated in organic Permian rocks or perhaps in rocks as old as Pennsylvanian. Upward migration by way of faults, fractures and joints transported the oil into the thick, porous sandstones of the uppermost Permian and lower Triassic. Removal of the water drive, which was the mechanism of the first upward migration, resulted in a later gravitational migration. In the Circle Cliffs area oil in massive middle Moenkopi sandstones (Triassic) may have originated in the organic lower Moenkopi and upper Kaibab Limestone (Permian). Faults, fractures and joints are important in controlling migration. The trap is a combination of the broad folding of the Circle Cliffs Uplift and stratigraphic variation in the middle Moenkopi sandstones.

RESERVES

To estimate roughly their size, deposits are grouped as follows (see table, sheet 2):

Classification	Gross Oil (or Bitumen) In Place
Giant	More than 500 million bbls.
Very Large	500 to 100 million bbls.
Large	100 to 10 million bbls.
Medium-small	10 to 0.5 million (500,000) bbls.
Minor	Less than 0.5 million (500,000) bbls.

Most size estimates are based on field inspection of deposits and on some published descriptions.

More specific estimates of gross oil in place result from calculations based on the following assumptions from field mapping observations and limited core data:

1. Areal extent of deposit in acres,
2. Average thickness of oil-impregnated rock in feet,
3. Porosity of impregnated rock (mostly assumed),
4. Percent of pore space filled with oil (mostly assumed), and
5. Percent of water saturation and/or shrinkage factors (assumed).

In most areas the deposit was assumed to persist for at least 1,320 feet back of the outcrop or for one mile where field mapping or core data indicated conditions of blanket saturation. In some deposits, blanket saturation over wide areas was assumed.

Measured, indicated and inferred/conjectural categories of reserves were calculated on the basis of percentages of the gross oil in place as judged by the reliability of data available on the deposit.

By averaging reserves assigned to each deposit, the gross oil in place in Utah's 53 deposits totals as follows:

	Billion barrels
Uinta Basin	8.8 to 11.3
Central southeast	14.1 to 17.9
Other areas	– (negligible)
Total	22.9 to 29.2

In the Uinta Basin, 95 percent of the total reserve is contained in four giant deposits and (98 percent) is contained in seven giant and very large deposits.

In central southeast Utah, 93.5 percent of the total reserve is contained in two giant deposits and 98.0 percent is contained in five giant and very large deposits.

No attempt was made to determine the recoverable portion of the total reserve.

EXPLORATION AND EXPLOITATION

Only one deposit, Daniels Canyon, is known to have been mined as a source of oil; the amount produced was very small. The Argyle Canyon, Asphalt Ridge, Sunnyside and Thistle deposits were mined for paving materials and mining continues at Asphalt Ridge.

Known exploration and exploitation activity is summarized as follows: (1973 to 1978 activity underlined):

Uinta Basin

Argyle Canyon—mined for paving material (Argulite);

Asphalt Ridge—mined for paving material, experimental mining and extraction for oil, *in situ* experiments (steam and solvent flood), extensive core drilling;

Asphalt Ridge Northwest—*in situ* experiments (steam and fire flood), extensive core drilling;

Daniels Canyon—mined for mineral wax and oil;

Lake Fork—core drilling;

P. R. Spring—core drilling, small-scale experimental mining;

Raven Ridge—experimental mining(?), core drilling;

Sunnyside—mined for paving material, experimental mining and extraction for oil, *in situ* experiments (thermal and steam flood), core drilling;

Thistle—mined for paving material;

Whiterocks—experimental mining and extraction for oil (pilot plants operated successfully for short period), *in situ* experiments (steam flood and thermal), core drilling;

Central Southeast

Circle Cliffs, West Flank—core drilling;

Cottonwood Draw—core drilling;

Family Butte—core drilling(?);

Poison Spring Canyon—core drilling;

Tar Sand Triangle—core drilling;

Ten Mile Wash—shallow core drilling;

White Canyon Flat—core drilling;

Wickiup—core drilling(?).

Lack of or difficult access to large sources of fresh water will hamper exploitation of these deposits as sources of oil in most areas. Water supplies may be available in parts of the Uinta Basin to support mining and processing operations on rich, concentrated deposits, such as Whiterocks and parts of Asphalt Ridge. Water supply is a serious factor in considering exploitation of the large potential reserves of the Tar Sand Triangle and Circle Cliffs.

Some deposits may become economically profitable to exploit because of the presence of valuable by-products associated with the oil or bitumen. These include uranium, vanadium, selenium and rare earth elements.

The Circle Cliffs deposits are partially within the extended boundaries of Capitol Reef National Park and the remainder of the deposits is within areas proposed for various scenic, recreation and wilderness preserves. Access to the deposits is severely limited.

The Tar Sand Triangle deposits lie mostly within the Glen Canyon National Recreation Area and immediately west of Canyonlands National Park. Access to the area for development purposes is severely restricted.

Other conflicts over land use and environmental considerations are expected to greatly influence development of all of Utah's deposits, particularly those susceptible to open-cut mining methods.

At present, both mining and *in situ* processes are contemplated as methods of development of this resource. From the point of view of conservation, the percent of recovery possible by mining, particularly open-cut methods, is an increasingly important factor to consider. Mining and processing oil-impregnated sandstone may result in more than 90 percent recovery of oil. *In situ* methods may achieve only 10 to 20 percent. The loss of the resource by *in situ* methods may be unacceptable in times of scarcity and great need in future decades.

ANALYSES OF EXTRACTED OIL

Assay and distillation analyses of 53 oils extracted from Utah's oil-impregnated sandstone deposits were tabulated by Wood and Ritzma (1972).

The oils vary widely in composition from deposit to deposit and considerably within some individual deposits. Sulfur content is the most obviously significant variable.

Uinta Basin

Sulfur content of oils originating in Paleocene or Eocene formations range from 0.19 to 0.82 percent in 39 samples from 16 deposits (Wood and Ritzma, 1972). In three instances, Asphalt Ridge, Asphalt Ridge Northwest and Whiterocks, the oils have migrated into older formations of Cretaceous and Jurassic age. Gwynn (1971, p. 17) reports sulfur contents of 34 samples of oil from the P. R. Spring deposit ranging from 0.22 to 0.42 percent.

Analyses of samples not previously reported from several deposits indicate contents as follows:

	Percent
Argyle Canyon	0.25, 0.35
Chapita Wells	0.66, 0.87
Daniels Canyon	0.62
Pariette	0.30
Raven Ridge	0.14 to 0.38 (13 samples)
Sunnyside	0.60
Thistle	1.07

Only the Thistle sample appears to deviate to any extent from the usual low sulfur content. The Daniels Canyon oil appears to be Tertiary oil which has migrated into overthrust Pennsylvanian-Permian Oquirrh Formation quartzites.

A significant contrast is the Split Mountain deposit found in the Permian Park City Formation. This undoubted Paleozoic oil has a sulfur content of 2.94 percent.

Central Southeast

Sulfur content of oils extracted from central southeast Utah deposits (summarized below) is significantly higher than that from Tertiary deposits in the Uinta Basin.

Deposit	Geologic Age	No. of Samples	Sulfur (percent)
Circle Cliffs[1]	Permian-Triassic	11	3.02-4.36
Circle Cliffs[1]	Triassic	1	2.37
Tar Sand Triangle[1]	Permian	5	3.13-4.25
Tar Sand Triangle[1]	Permian	1	6.27
San Rafael Swell (5 deposits)	Triassic	9	2.57-5.08
Cottonwood Draw	Triassic	1	1.64
Thousand Lake Mountain	Jurassic	1	4.48
White Canyon	Permian	1	2.73

[1] Wood and Ritzma, 1972.

The two Jurassic deposits sampled, Ten Mile Wash and Salt Wash, yielded oil with sulfur contents of 4.16 and 2.16 percent, respectively.

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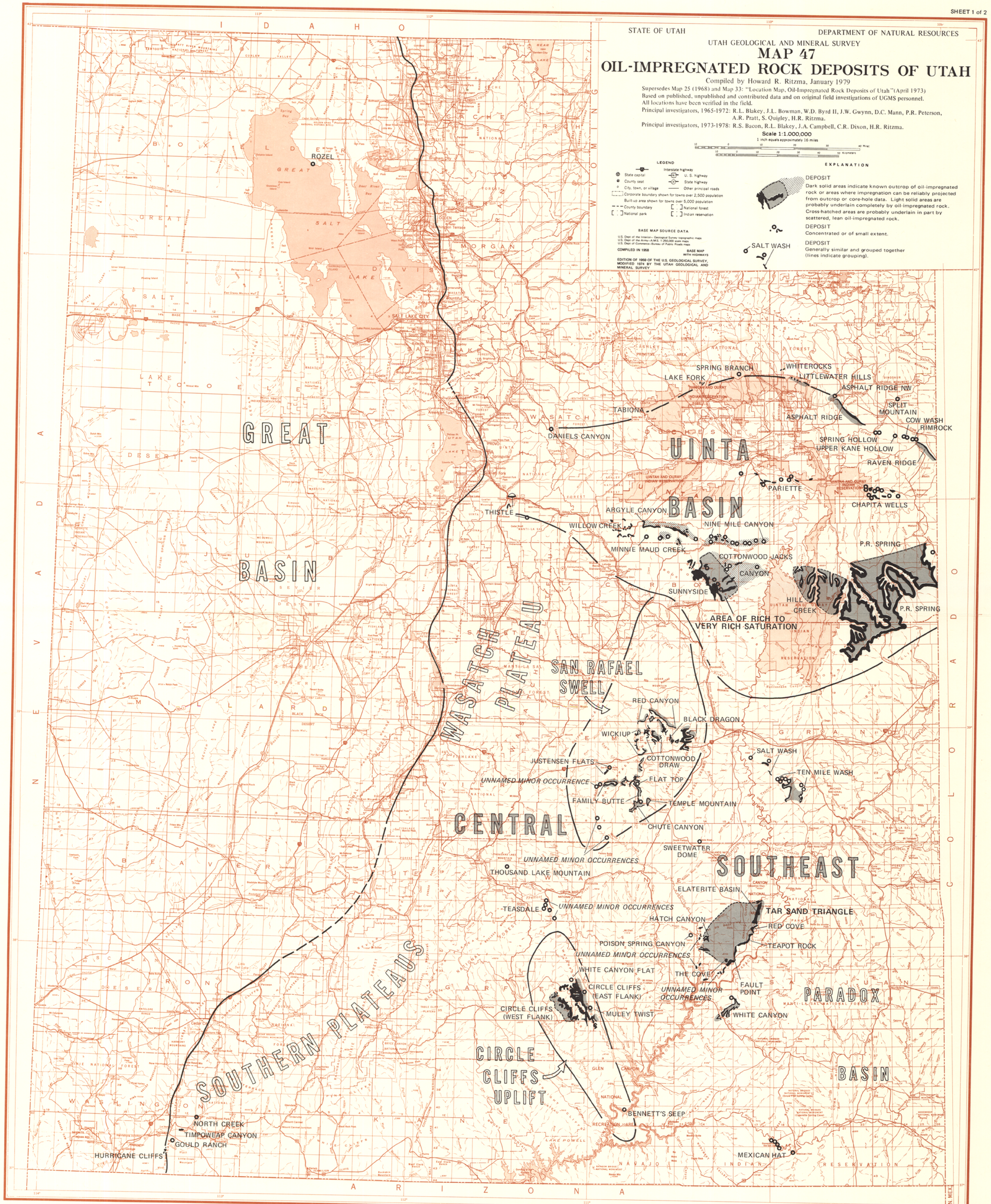

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OIL- IMPREGNATED ROCK DEPOSITS OF UTAH

A DEPOSIT (Name previously used or name of smaller occurrence within deposit-see list at right for comparison with nomenclature used in Map 25, 1968)	B LOCATION Township (s) and Range (s); Section (s) if localized UM = Uinta Meridian	C COUNTY (S)	D FORMATION (S) IN WHICH DEPOSIT OCCURS (Geologic age)	E DOMINANT LITHOLOGIES	F SIZE OF DEPOSIT	G GROSS OIL IN PLACE (million barrels[1]) m= measured i = indicated i/c= inferred or conjectural	H SOURCE OF DATA IN COLUMNS F AND G
UINTA BASIN							
ARGYLE CANYON (Indian Canyon, Lake Canyon)	T. 11 S., Rs. 11, 12 and 13 E.; T. 10 S., R. 11 E.; T. 7 S., R. 7 W. (UM)	Duchesne	Green River Fm. (Eocene), deltaic facies, Parachute Creek Mbr. and Evacuation Creek Mbr. (in ascending order)	Sandstone and siltstone with limestone	Large	50 to 75	Estimate by UGMS, 1978
ASPHALT RIDGE	Ts. 4, 5 and 6 S., Rs. 20, 21 and 22 E.	Uintah	Duchesne River Fm. (Eocene) and Rimrock Ss. Mbr. of Mesaverde Fm. (U. Cret.)	Sandstone and siltstone	Giant	1,048 435 m 438 i 175 i/c	Spieker, 1930, Covington, 1963 1964a and b, 1965; Kayser, 1966; combined with estimates by UGMS, 1972 and contributed data
ASPHALT RIDGE, NORTHWEST	T. 4 S., R. 20 E., Secs. 23 and 24	Uintah	Asphalt Ridge and Rimrock Mbrs. of Mesaverde Fm. (U. Cret.)	Sandstone	Very large (much in subsurface)	100 to 125	Estimate by UGMS, 1978 combined with contributed data
CHAPITA WELLS	T. 9 S., Rs. 21 and 22 E.	Uintah	Uinta (Fm. (Eocene)	Sandstone	Medium-small	7.5 to 8	Estimate by UGMS, 1972
COTTONWOOD-JACKS CANYON	Ts. 11, 12 and 13 S., Rs. 14, 15 16, 17 and 18 E.	Carbon and Duchesne	Green River Fm. (Eocene), deltaic facies	Sandstone and siltstone	Large	20 to 25	Estimate by UGMS, 1978
COW WASH	T. 6 S., R. 24 E., Secs. 20 and 21	Uintah	Green River Fm. (Eocene)	Sandstone and conglomerate	Medium-small	1.0 to 1.2	Estimate by UGMS, 1972
DANIELS CANYON	T. 6 S., R. 6 E. SE NW SW Sec. 10	Wasatch	Oquirrh Fm. (Permo-Pennsylvanian)	Limestone and quartzite	Minor	-	Estimate by UGMS, 1972
HILL CREEK	Ts. 13, 14 and 15 S., Rs. 18, 19, 20 and 21 E.	Uintah	Green River Fm. (Eocene), Douglas Creek Mbr.	Sandstone and siltstone	Giant	1,160 350 m 480 i 330 i/c	Estimate by UGMS, 1972
LAKE FORK (Lake Fork-Yellowstone, Yellowstone, Black Diamond)	T. 1 N., R. 4 W., Secs. 5 and 6; T. 1 N., R. 5 W., E½ NE Sec. 1 (UM)	Duchesne	Duchesne River Fm. (Eocene)	Sandstone	Medium-small	6.5 to 10	Estimate by UGMS, 1972 combined with contributed data
LITTLEWATER HILLS (Deep Creek, Deep Creek Nose)	Ts. 1 and 2 N., Rs. 1 and 2 E. (UM); T. 3 S., R. 19 E., Sec. 34	Uintah	Duchesne River Fm. (Eocene)	Sandstone and conglomerate	Large	10 to 12	Estimate by UGMS, 1972
MINNIE MAUD CREEK (Indian Canyon, Lake Canyon)	Ts. 11 and 12 S., Rs. 11, 12 and 13 E.	Duchesne and Carbon	Green River Fm. (Eocene), deltaic facies and Parachute Creek Mbr.	Sandstone and siltstone with limestone	Large	10 to 15	Estimate by UGMS, 1978
NINE MILE CANYON	T. 11 S., Rs. 14, 15, 16 and 17 E.	Duchesne	Green River Fm. (Eocene), deltaic facies and Parachute Creek Mbr.	Sandstone and siltstone	Medium-small	5 to 10	Estimate by UGMS, 1972
PARIETTE (Myton Bench, South Myton Bench, Myton)	T. 4 S., Rs. 2 W., 1 and 2 E. (UM); T. 8 S., Rs. 17 and 18 E.	Duchesne and Uintah	Uinta Fm. (Eocene)	Sandstone and siltstone	Large	12 to 15	Estimate by UGMS, 1972
P. R. SPRING (Peor Springs, Dragon-Asphalt Wash, Seep Canyon, Roan Cliffs, Evacuation Creek)	Ts. 12 thru 17 S., Rs. 21 thru 26 E.	Uintah and Grand	Green River Fm. (Eocene), Douglas Creek Mbr. and Parachute Creek Mbr. (very minor)	Sandstone and siltstone	Giant	4,000 to 4,500 2,500 m 1,200 i remainder i/c	Byrd, 1970, combined with estimate by UGMS, 1972
RAVEN RIDGE	Ts. 6 and 7 S., Rs. 24 and 25 E.	Uintah	Green River Fm. (Eocene), Douglas Creek Mbr. (minor) and Parachute Creek Mbr.	Sandstone and siltstone	Large	75 to 100	Estimate by UGMS, 1976
RIM ROCK (Northwest Raven Ridge)	T. 6 S., R. 24 E., Secs. 22, 23, 25 and 26	Uintah	Wasatch Fm. (Eocene) and basal Green River Fm. (Eocene)	Sandstone	Large	25 to 30	Estimate by UGMS, 1968, 1978
SPLIT MOUNTAIN (Red Wash)	T. 4 S., R. 23 and 24 E. Thru SE¼ of twp.	Uintah	Park City Fm. (Permian)	Limestone	Minor	–	Estimate by UGMS, 1968, 1972
SPRING BRANCH	T. 2 N., R. 3 W. (UM). NE NE Sec. 24	Duchesne	Duchesne River Fm. (Eocene)	Sandstone and conglomerate	Medium-small	1.5 to 2	Estimate by UGMS, 1972
SPRING HOLLOW	T. 6 S., R. 23 E., S½ Sec. 18	Uintah	Duchesne River Fm. (Eocene)	Sandstone	Minor	–	Estimate by UGMS, 1968, 1978
SUNNYSIDE (Tidewell, Rideout)	Ts. 12, 13 and 14 S., Rs. 13, 14 and 15 E.	Carbon	Upper Wasatch Fm. (Eocene) and basal Green River Fm. (Eocene)	Sandstone and siltstone	Giant	3,500 to 4,000 1,250 m 1,750 i remainder i/c	Holmes, Page and Averitt, 1948; Holmes and Page, 1956; Ball Associates, 1965; combined with estimate of UGMS, 1972 and contributed data.
TABIONA (North Tabiona)	T. 1 S., R. 7 W. (UM), SE Sec. 16 and S½ S½ Sec. 17	Duchesne	Currant Creek Fm. (Paleocene-Eocene) and Duchesne River Fm. (Eocene)	Sandstone	Medium-small	4.6 1.3 m 1.6 i 1.7 i/c	Estimate by UGMS, 1972
THISTLE (Oil Hollow)	Ts. 9 and 10 S., Rs. 4 and 5 E; T. 9 S., R. 4 E., Secs. 26, 27 and 28; T. 10 S., R. 4 E., Secs. 3, 4, 9 and 10; T. 10 S., R. 5 E., Sec. 28	Utah	Green River Fm. (Eocene)	Sandstone with some oolitic and coquinal limestone	Medium-small	2.2 to 2.5	Estimate by UGMS, 1972
UPPER KANE HOLLOW	T. 6 S., R. 23 E., Secs. 13 and 24	Uintah	Green River Fm. (Eocene)	Sandstone	Minor	–	Estimate by UGMS, 1972
WHITEROCKS	T. 2 N., R. 1 E. (UM), Secs. 17, 18 and 19	Uintah	Navajo Ss. (Jurassic)	Sandstone	Very large	65 to 125 50 m 15 i remainder i/c	Severy, 1943; Covington, 1963, 1964a and b, 1965; combined with estimate by UGMS and contributed data
WILLOW CREEK (Argyle Canyon)	T. 11 S., Rs. 9 and 10 E.; Ts. 6 and 7 S., Rs. 8 and 9 W. (UM)	Duchesne, Utah and Wasatch	Green River Fm. (Eocene)	Sandstone and siltstone with limestone	Large	10 to 15	Estimate by UGMS, 1978
CENTRAL SOUTHEAST							
BENNETTS SEEP	T. 40 S., R. 10 E. Section not certain (Submerged by Lake Powell)	Kane	Moenkopi Fm. (Triassic)	Sandstone	Minor	–	UGMS estimate, 1969
BLACK DRAGON (Black Box, Jackass Bench)	T. 21 S., Rs. 12, 13 and 14 E; T. 22 S., R. 13 E.	Emery	Moenkopi Fm. (Triassic)	Sandstone	Very large	100 to 125	UGMS estimate, 1972
CHUTE CANYON (San Rafael Swell, South group)	Ts. 24 and 25 S., Rs. 10 and 11 E.	Emery	Moenkopi Fm. (Triassic)	Sandstone	Large	50 to 60	UGMS estimate, 1972
CIRCLE CLIFFS, EAST FLANK (Wagon Box Mesa)	T. 33 S., R. 8 E.; T. 34 S., Rs. 7 and 8 E.; Ts. 35 and 36 S., Rs. 8 and 9 E.	Garfield	Moenkopi Fm. (Triassic)	Sandstone and siltstone	Giant	860 420 m 340 i 100 i/c	UGMS estimate, 1970
CIRCLE CLIFFS, WEST FLANK	T. 34 S., Rs. 6 and 7 E.; T. 35 S., Rs. 7 and 8 E.	Garfield	Moenkopi Fm. (Triassic)	Sandstone and siltstone	Very large	447 287 m 90 i 70 i/c	UGMS estimate, 1970
COTTONWOOD DRAW	T. 21 S., Rs. 11 and 12 E.	Emery	Moenkopi Fm. (Triassic)	Sandstone, siltstone and minor limestone	Large	75 to 80	UGMS estimate, 1972
FAMILY BUTTE (San Rafael Swell, South group)	T. 22 S., R. 11 E.; Ts. 23 and 24 S., Rs. 9, 10 and 11 E.	Emery	Moenkopi Fm. (Triassic)	Sandstone	Very large	100 to 125	UGMS estimate, 1972
FLAT TOP (San Rafael Swell, South group)	T. 24 S., R. 11 E., Secs. 32 and 33	Emery	Mossback Ss. Mbr. of Chinle Fm. (Triassic	Sandstone	Minor	.25 to .50	UGMS estimate, 1967 and 1972
JUSTENSEN FLAT (Copper Globe)	T. 23 S., R. 9 E., E½ Sec. 10 and Secs. 16, 20 and 21	Emery	Navajo Ss. and Kayenta Fm. (Jurassic)	Sandstone	Minor	–	UGMS estimate, 1972
MULEY TWIST (Bob Steed)	T. 35 S., R. 8 E., Sec. 10	Garfield	Shinarump Mbr. of Chinle Fm. (Triassic)	Sandstone	Minor	–	UGMS estimate, 1967
POISON SPRING CANYON	T. 31 S., R. 13 E., Secs. 23 and 24	Garfield	Moenkopi Fm. (Triassic)	Sandstone	Medium-small	1.0 to 1.2	UGMS estimate, 1968
RED CANYON (Woodward Wash)	Ts. 20 and 21 S., Rs. 10, 11 and 12 E.; T. 21 S., R. 13 E.	Emery	Moenkopi Fm. (Triassic)	Sandstone	Large	60 to 80	UGMS estimate, 1972
SALT WASH	T. 22 S., R. 16 E., NW Sec. 25; T. 22 S., R. 17 E., Secs. 33, 34 and 35; T. 23 S., R. 17 E., Secs. 2, 3, 11, 14, 23 and 24	Grand	Salt Wash Mbr. of Morrison Fm. and Entrada Ss. (Jurassic)	Sandstone	Minor	.20 to .25	UGMS estimate, 1967 and 1970
SAN RAFAEL SWELL, miscellaneous localities, unnamed (San Rafael Swell, South group)	T. 24 thru 26 S., R. 9 E.	Emery	Mossback Mbr. of Chinle Fm. (Triassic) and Kaibab Ls. (Permian)	Sandstone, limy sandstone, sandy limestone and limestone	Minor	–	UGMS estimate, 1972
SWEETWATER DOME	T. 26 S., R. 14 E., Secs. 33 and 34	Emery	Curtis Fm. and Entrada Ss. (Jurassic)	Sandstone	Minor	.10 to .12	UGMS estimate, 1967
TAR SAND TRIANGLE including ELATERITE BASIN, FAULT POINT, HATCH CANYON RED COVE, TEAPOT ROCK and THE COVE areas (Cove, Fiddler Cove Canyon, French Seep, North Hatch Canyon, Orange Cliffs, South Hatch Canyon)	Ts. 29, 30, 30½, 31, 32 and 33 S., Rs. 14, 15, 16 and 17 E.	Garfield and Wayne	ELATERITE BASIN White Rim FAULT POINT Cedar Mesa and White Rim HATCH CANYON Moenkopi, basal, White Rim and Shinarump RED COVE White Rim and Cedar Mesa TEAPOT ROCK White Rim and Cedar Mesa THE COVE White Rim, Moenkopi, Basal, and Shinarump White Rim and Cedar Mesa are sandstone members of Cutler Fm. (Permian) Moenkopi Fm. (Triassic) Shinarump Conglomerate is basal member of Chinle Fm. (Triassic)	Sandstone and conglomerate	Giant	12,500 to 16,000[2] 2,300 m 3,800 i 6,400 to 9,900 i/c	Covington, 1965; Schick, 1966; Bowman, 1969a and b; Ritzma, 1969; UGMS estimate 1972
TAR SAND TRIANGLE minor occurrences, unnamed	Ts. 32½ and 33 S., Rs. 14 and 15 E.	Garfield	White Rim Sandstone Mbr. of Cutler Fm. (Permian)	Sandstone	Medium-small	3 .5 m 1.0 i 1.5 i/c	Bowman, 1969a and b; UGMS estimate, 1972
TEASDALE, miscellaneous localities, unnamed (Capitol Reef, Miners Mountain)	T. 29 S., R. 6 E.; T. 30 S., Rs. 6 and 7 E.	Wayne	Moenkopi Fm. (Triassic) and Kaibab Ls. (Permian)	Sandstone, limy sandstone and limestone	Minor	–	UGMS estimate, 1967 and 1972
TEMPLE MOUNTAIN (San Rafael Swell, South group)	Ts. 24 and 25 S., R. 11 E.	Emery	Mossback Mbr. of Chinle Fm. (Triassic) and Wingate Ss. (Triassic)	Sandstone	Minor	–	UGMS estimate, 1967
TEN MILE WASH	Ts. 23 and 24 S., Rs. 18 and 19 E.	Grand	Burro Canyon Fm. (Cretaceous), Brushy Basin and Salt Wash Mbrs. of Morrison Fm. (Jurassic), Moab Ss. Tongue and main body of Entrada Ss. (Jurassic)	Sandstone	Medium-small	6 1.5 m 2.0 i 2.5 i/c	UGMS estimate, 1970
THOUSAND LAKE MOUNTAIN	T. 28 S., R. 4 E., NE SE Sec. 10	Wayne	Navajo Ss. (Jurassic)	Sandstone	Minor	–	UGMS estimate, 1971
WHITE CANYON	Ts. 34 and 35 S., Rs. 15 and 16 E.	San Juan	Hoskinni Mbr. of Cutler Fm. (Permian)	Sandstone	Large	12 to 15	UGMS estimate, 1972
WHITE CANYON FLAT	T. 33 S., R. 7 E., Secs. 35 and 36	Garfield	Shinarump Mbr. of Chinle Fm. (Triassic)	Sandstone	Medium-small	2.8 1.8 m .4 i .6 i/c	UGMS estimate, 1970
WICKIUP	Ts 21 and 22 S., Rs. 10 and 11 E	Emery	Moenkopi Fm. (Triassic)	Sandstone, siltstone and minor limestone	Large	60 to 75	UGMS estimate, 1972
OTHER AREAS							
GOULD RANCH	T. 42 S., R. 13 W. E½ Sec. 12	Washington	Timpoweap Mbr. of Moenkopi Fm. (Triassic)	Calcarenite (limestone)	Minor	–	Blakey, in press; UGMS estimate, 1978
HURRICANE CLIFFS	T. 42 S., R. 13 W., Secs. 27 and 34	Washington	Timpoweap Mbr. of Moenkopi Fm. (Triassic)	Limestone	Minor	–	Blakey, in press UGMS estimate, 1978
MEXICAN HAT	Ts. 41 and 42 S., Rs. 17, 18 and 19 E.	San Juan	Rico Fm. (Pennsylvanian-Permian); Hermosa Fm. (Pennsylvanian)	Limestone and sandy limestone	Medium-small	.4 to .5	UGMS estimate, 1972
NORTH CREEK	T. 41 S., R. 11 W. NW¼ Sec. 6	Washington	Upper Mbr. of Moenkopi Fm. (Triassic)	Sandy shale, shale	Minor	–	Blakey, in press; UGMS estimate, 1978
ROZEL	T. 8 N., R. 7 W., Secs. 8, 9 and 16	Box Elder	Lake sediments (Recent)	Oolitic mud, salt	Minor	–	UGMS estimate, 1972
TIMPOWEAP CANYON (Virgin River)	T. 41 S., R. 12 W. Secs. 19, 20, 21 and 28	Washington	Timpoweap Mbr. of Moenkopi Fm. (Triassic)	Calcarenite (limestone)	Medium small	0.5 to 1.0	Blakey, in press; UGMS estimate, 1978

[1] Barrel = 42 gallons.
[2] About 99.3% of 12.5 billion bbls. is contained in White Rim, 0.7% in Cedar Mesa and less than 0.1% in other formations.

UTAH GEOLOGICAL AND MINERALOGICAL SURVEY

MAP 47, SHEET 2

CHANGES IN NOMENCLATURE OF DEPOSITS
From Map 25 (1968) to Map 33 (1973)

UINTA BASIN

NEW DEPOSITS
- Cottonwood-Jacks Canyon
- Cow Wash
- Daniels Canyon
- Minnie Maud Creek–formerly part of Argyle Canyon
- Nine Mile Canyon
- Thistle
- Willow Creek–formerly part of Argyle Canyon

RENAMED DEPOSITS
- Lake Fork–formerly Lake Fork-Yellowstone
- Littlewater Hills–formerly Deep Creek Nose
- Pariette – formerly Myton Bench
- Split Mountain–formerly Red Wash

NAMES ABANDONED
- Deep Creek Nose–changed to Littlewater Hills
- Dragon-Asphalt Wash–combined with P.R. Spring
- Lake Fork-Yellowstone-changed to Lake Fork
- Myton Bench–changed to Pariette
- Red Wash – changed to Split Mountain

DEPOSITS ELIMINATED
- Starr Flat–not found
- Whiterocks, South–not found

CENTRAL SOUTHEAST

NEW DEPOSITS
- Black Dragon– expansion of Black Box
- Chute Canyon
- Circle Cliffs, East Flank–formerly part of Circle Cliffs
- Circle Cliffs, West Flank–formerly part of Circle Cliffs
- Cottonwood Draw
- Family Butte
- Justensen Flat
- Red Canyon–expansion of Woodward Wash
- Thousand Lake Mountain
- Wickiup

RENAMED DEPOSIT
- Tar Sand Triangle–includes six formerly separate deposits

NAMES ABANDONED
- Black Box–incorporated into Black Dragon
- Circle Cliffs–east and west flanks considered separate
- Cove, The–area within Tar Sand Triangle
- Elaterite Basin–area within Tar Sand Triangle
- Fault Point–area within Tar Sand Triangle
- Hatch Canyon–area within Tar Sand Triangle
- Tar Cliffs–area within Tar Sand Triangle
- Teapot Rock–area within Tar Sand Triangle
- Woodward Wash–incorporated into Red Canyon

From Map 33 (1973) to Map 47 (This Publication)

OTHER AREAS

NEW DEPOSITS
- Gould Ranch
- Hurricane Cliffs
- North Creek
- Timpoweap Canyon–formerly Virgin River

NAMES ABANDONED
- Virgin River– area within Timpoweap Canyon

DEPOSITS ELIMINATED
- Hurricane Fault– not found

Percent Sulfur in Oils Extracted from Oil-Impregnated Rock

	No. of Samples	Percent Range	Percent Average
UINTA BASIN			
DEPOSITS IN TERTIARY ROCKS			
Argyle Canyon	2	0.25-0.35	0.30
Asphalt Ridge	2	0.62-0.76	0.69
Chapita Wells	3	0.28-0.87	0.60
Cow Wash	1	–	0.39
Hill Creek	2	0.25-0.40	0.32
Lake Fork	2	0.44-0.46	0.45
Littlewater Hills	1	–	0.41
Pariette	1	–	0.30
P.R. Spring (Wood and Ritzma, 1972)	8	0.33-0.45	0.43
P.R. Spring (Gwynn, 1971, p. 71)	34	0.22-0.42	0.33
Raven Ridge (Wood and Ritzma, 1972)	2	0.27-0.43[1]	0.35
Raven Ridge (S. Quigley, unpublished)	13	0.12-0.38	0.22
Rim Rock	4	0.33-0.43	0.39
Spring Branch	2	0.47-0.82	0.64
Spring Hollow	1	–	0.76
Sunnyside	2	0.50-0.60	0.55
Tabiona	3	0.20-0.29	0.23
Thistle	1	–	1.07
Upper Kane Hollow	1	–	0.32
DEPOSITS IN MESOZOIC ROCKS[2]			
Asphalt Ridge (U. Cret.)	4	0.19-0.39	0.29[2]
Asphalt Ridge, Northwest (U. Cret.)	2	0.35-0.40	0.38[2]
Whiterocks (Jurassic)	3	0.41-0.48	0.45[2]
DEPOSITS IN PALEOZOIC ROCKS			
Daniels Canyon (Perm.-Penn.)[2]	1	–	0.62[2]
Split Mountain (Perm.)[3]	1	–	2.94[3]
CENTRAL SOUTHEAST			
DEPOSITS IN JURASSIC ROCKS			
Salt Wash	1	–	2.16
Ten Mile Wash	1	–	4.16
Thousand Lake Mountain	1	–	4.48
DEPOSITS IN TRIASSIC ROCKS			
Black Dragon	5	2.84-5.08	3.82
Circle Cliffs, East Flank	1	–	3.63
Circle Cliffs, West Flank	5	2.37-4.19	3.36
Cottonwood Draw	2	1.64-3.22	2.43
Family Butte	2	3.46-3.65	3.56
Muley Twist	2	3.82-4.09	3.96
Red Canyon	1	–	2.57
White Canyon Flat	3	3.02-3.91	3.49
DEPOSITS IN PERMIAN ROCKS			
Tar Sand Triangle	15	2.67-6.27	3.56
White Canyon	1	–	2.73

[1] One anomalous result, Sample 67-5A (Wood and Ritzma, 1972) could not be confirmed by extensive resampling. Anomalous high percent sulfur is considered to be laboratory error.
[2] All considered to be Tertiary oils migrated into older rocks.
[3] Considered to be only *in situ* Paleozoic sample in Uinta Basin.

Areal Extent, Number and Thickness of Pay Zones, Overburden Thickness and Gross Oil in Place in Selected Oil-Impregnated Rock Deposits (See Notes)

Deposit	Areal Extent (square miles)	Number of Principal Pay Zones	Gross Thickness of Pay, Range (feet)	Overburden Thickness, Range (feet)	Gross Oil in Place (barrels: see accompanying table)
UINTA BASIN					
Argyle Canyon	7-15	3 to 5	15-60	0-500+	50-75 million
Asphalt Ridge	20-25	2 to 5	10-135	0-500+	1.048 billion
Asphalt Ridge, NW	5-10	1 to 3	20-300	0-275	100-125 million
Chapita Wells	.35-1.0	1 to 3	5-30	0-300	7.5-8.0 million
Cow Wash	0.08-0.10	1	5-25	0-200	1.0-1.2 million
Hill Creek	115-125	1 to 3	5-35	0-500+	1.16 billion
Lake Fork	0.3-0.5	1 to 3	5-70	0-450	6.5-10.0 million
Littlewater Hills	0.5-1.75	1 or 2	5-90	0-500+	10-12 million
Minnie Maud Creek	0.5-3.5	1 to 4	5-15	0-500+	10-15 million
Pariette	1.2-1.4	1 or 2	5-32	0-300	12-15 million
P. R. Spring	240-270	2 to 6	10-80	0-500+	4.0-4.5 billion
Raven Ridge	20-25	1 to 4	5-48	0-500+	75-100 million
Rim Rock	2.0-3.0	1 to 3	5-95	0-500+	25-30 million
Spring Branch	0.1-0.2	1	5-250	0-350	1.5-2.0 million
Sunnyside	35-90	3 to 12	15-550	0-500+	3.5-4.0 billion
Tabiona	.15	1 to 3	5-150	0-400	4.6 million
Whiterocks	0.6-0.75	1	1,000±	0-500	65-125 million
CENTRAL SOUTHEAST					
Circle Cliffs, East Flank	21.1	1 to 3	5-260	0-500+	860 million
Circle Cliffs, West Flank	6.6	1 or 2	5-310	0-500+	447 million
Cottonwood Draw	10.5-12.0	1 to 3	5-65	0-500+	75-80 million
Poison Spring Canyon	0.6-0.8	1 or 3	5-24	0-500+	1.0-1.2 million
Tar Sand Triangle	200-230	1 or 2	5-300+	0-500+	16 billion
Ten Mile Wash	5.0-6.5	1 to 4	5-30	0-500+	6.0 million
White Canyon Flat	0.3-0.4	1	5-21	0-220	2.8 million

Notes:

24 deposits have been mapped and sampled in sufficient detail to provide the above information relating to possible development.

Areal Extent is generally given as a range, the minimum figure being the measured areal extent, the maximum being the indicated extent.

Number of pay zones is the number of oil-impregnated rock units five or more feet thick likely to be encountered at any one location within the measured or indicated areal extent of the deposit.

Gross thickness of pay is the total thickness of the combined pay zones likely to be encountered at any one location within the measured or indicated areal extent of the deposit. Cutoff of a "pay" zone is five feet.

Overburden thickness is from outcrop to 1,320 feet (0.25 mile) from outcrop. Variations shown emphasize importance of topography in evaluation of these deposits.

Gross oil in place has been revised for Argyle Canyon; Asphalt Ridge, NW; Minnie Maud Creek, Raven Ridge and Rim Rock Deposits from Map 33 (1973) to this publication